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Tab. II.

Fig: 4.

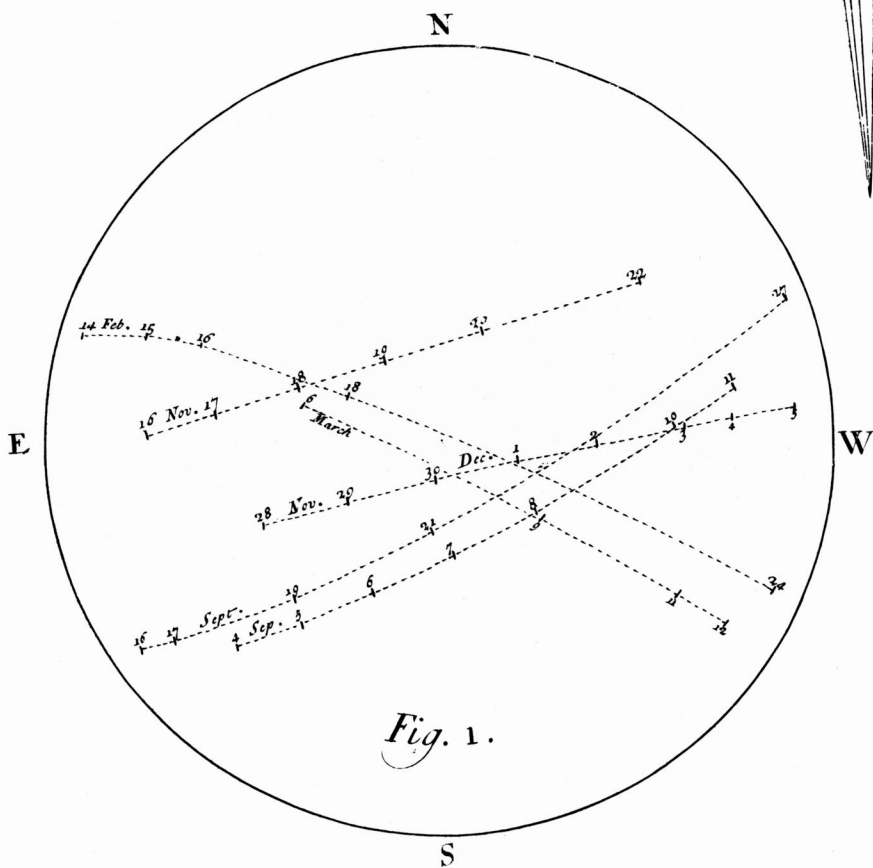


Fig. 1.

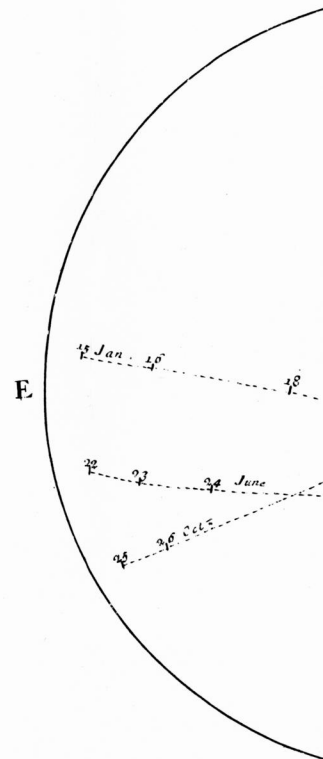


Fig. 4.

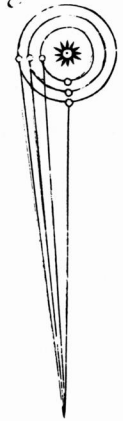
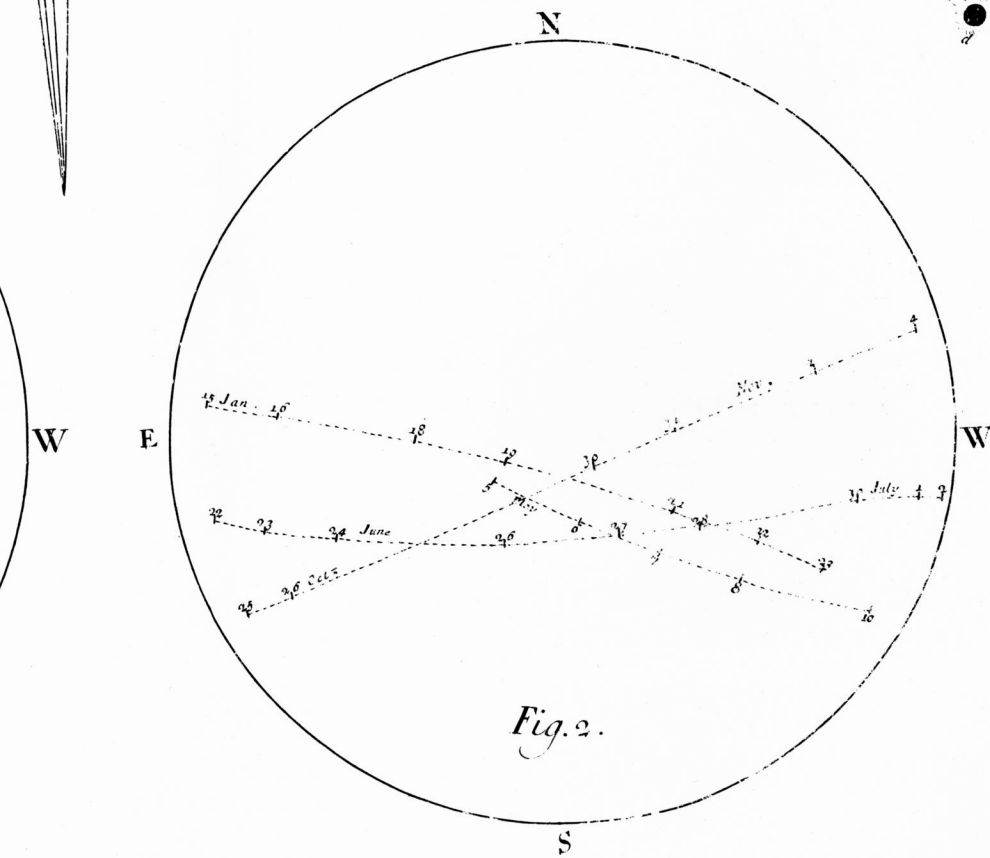
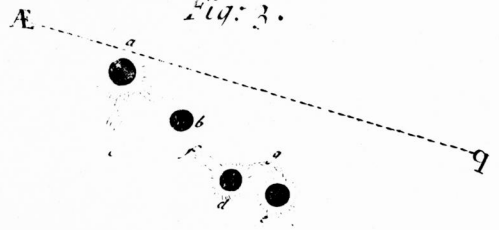


Fig. 3.



II. *Observations upon the Spots that have been upon the Sun, from the Year 1703 to 1711. With a Letter of Mr. Crabtree, in the Year 1640. upon the same Subject. By the Reverend Mr William Derham, F. R. S.*

WHEN Spots on the Sun were more rare, than for these three or four Years last past they have been, this most Illustrious Society was pleased to accept of my Account of some of the first that for divers Years had been seen: Which for their Novelty were published, with some others, in the *Phil. Transact.* No. 288. But for as much as those Observations of mine were imperfect, as I there confess'd, therefore to make some amends, I will give a better Account of the *Spots* and *Faculae* that have been seen on the Sun since; there having, I suppose, few of those Appearances escap'd my Sight, since their first being seen in 1703; and because I am now better provided with competently good Instruments to take their Places on the Sun, viz. a *Micrometer* (after Mr. Gascoign's manner) to take their distance from the Sun's Northern or Southern Limb, which is parallel with the Pole of the Earth; and an *Half-Seconds Movement*, to measure their distance from the Sun's Eastern or Western Limb.

In this following Table, may be seen at one view, what *Spots* or *Faculae* fell under my cognizance.

*A Table of all the Spots and Faculae on the Sun, visible
at Upminster, since July 1703.*

1703.	Jun. 23. none	22	50	1707.	27
Octob. 9	Some Vanished 24	* 23	April 2	Feb. 14	No Spot nor *
10	July 18	June 22	Vanished 3	15	
11	20	23	June 7	16	Octob. 31
Nov. 19	21	24	8	18	Nov. 1
22	* 23	26	July 24	24	4
	Sept. * 10	27	25	March 6	8
1704	nothing 14	28	Sept. 4	9	10
Jan. 16	18	30	5	11	N.B. This 15
17	* 21	July * 1	6	12	Nov. 15, another 16
18	Nov 17	* 3	7	14	Spot arose 17
19	18	24	8	18	on the Eastern 18
21	21	Sept. 30	10	21	side of the Disk, whilst 19
22	Dec. * 2	Octob. 2	Faint 11	Jun. * 29	this was on the 20
23		3	Extinct 12	Extinct 30	Western. 22
Jan. 30	1705.	5	Oct. * 29	July 1	
Feb. 23	Jan. 1	6	Nov. 5	Languid 2	
25	2	7	Faint * 8	Scarce } 4	
Mar. 7	3	25	28	visible } 5	
8	* 25	26	29	More } 6	
9	Feb. * 19	30	30	Extinct 6	
10	March 14	31	Dec. 1	Appears 8	
11	16	Nov. 2	2	* 10	
13	April 1	* 21	3	Aug. * 31	
April 11	May 5	1706.	4	Sept. * 12	
12	6	Feb. 7	5	16	
13	7	Mar. 7	22	Spot & * 17	
May 1	8		* 31	19	
* 11	* 10	27		21	

In this Table the *Faculae* are noted with an Asterisk; and the duration of every Appearance of the same Spots or *Faculae*, or the time they disappeared, with a Line: And where any thing remarkable occur'd, that could be briefly noted, I have taken notice of it in the Table.

There are many other things that I took notice of in viewing the Spots and *Faculae*, which would be troublesome to the Society, and indeed needless to particularly mention, since so many Accounts have been already given of them. But some things I shall select, as may be of use to, and gratify such as are curious in these Matters.

And first, as to the Figure of the Spots. They are well known to change frequently; and therefore I think it of little use to give their Figures every time I observ'd them. But it is somewhat remarkable, that the Spots generally appear longish near the extreme Parts of the Disk. If they are never so round near the middle of the Disk, they become longer and longer towards the Extremes, till (at going off) they seem to be nearly a strait Line, nearly parallel to the Suns Limb. Which is a manifest Argument, that the Sun is a Globe, and that these Spots are on, or very near its Surface.

Another thing remarkable is, The Mutability of the Shape of the Spots. I have more than once manifestly perceived them to change in the very time I have been looking upon them. Thus Nov. 19. 1703. I saw three or more Spots not far off the middle of the Disk; and whilst I was looking upon them, they seemed to vary, both as to their Shape and Strength; sometimes seeming longer, sometimes shorter; sometimes spifs, sometimes languid. And this they seemed to do, not only through my 16 Feet Tube, (which I thought at first was from the different Disposition of my Eye) but also when I received the Suns Image through a Six Feet Telescope,

Ilescope, on a white Paper, in a darkened Room. These mutable Spots the Weather hindred me from seeing again till *November* the 22d. following; and then they were become only like a thin Smoak, or *Nebula*.

So again *April* 11. 1704. there were divers Spots with *Umbrae* about them. These *Umbrae*, or *Nebulae*, I could plainly perceive, whilst I was looking on them, to be sometimes very faint and thin, and sometimes much darker and thicker. These *Maculae* and *Umbrae* I observed suddenly brake out in the Sun: For, on *April* 9. the Disk was free. But this *April* 11. last mentioned, I perceived them advanced near a quarter part on the Disk: And consequently they brake out in the Sun within 48 hours before. On *April* 13: the Spots were become *Umbrae*, in the Morning; and at Four of Clock in the Afternoon, there were no Remains of either *Maculae* or *Umbrae*.

From this short continuance of these Spots on the Sun, it is more than probable, they were in a perpetual Flux and Change; and that those Mutations which I perceived in them, whilst I was looking on them, were real, not imaginary.

Also it may be farther remarked, (which I have frequently observed, and which as I remember *Scheiner* observ'd long ago) That those Spots and *Umbrae* which suddenly arise, do as suddenly decay, and are soon extinct. And such Spots, I have farther observed, do seldom turn to *Faculae*, as they commonly do when longer on the Sun, as I shall observe by and by.

Again, *May* 5. 1705. I could perceive two Spurs or Branches (running from a Spot) to change, and be sometimes darker, sometimes thinner.

So *March* 30. 1706. I observ'd such another Variation. This Day, or but little before, Spots with *Faculae* arose in the Sun, which remained not above three Days on him. One of these Spots I could manifestly perceive

ceive to be sometimes quite extinct, and then again immediately to appear: And the *Faculae* also, in half an hours time, had plainly alter'd their Shapes.

October 29. the same Year, I could plainly perceive the *Maculae* and *Faculae* both to change: And whilst I was carefully viewing them, I saw a Spot arise in one of the brightest *Faculae*, and again nearly disappear; and then again appear strong and spifs. I should have been glad to have seen how they appear'd next Day; but the Weather was Stormy, Cloudy, and Wet for several Days after.

Another thing I have observed (and not having the Book by me, I forget whether *Scheiner* observed the same or not) is, That the *Maculae* do generally, if not always, become *Nebulae* or *Umbrae* before they quite vanish; and after that, very frequently turn to *Faculae*, or bright golden Spots, more illustrious and fulgid than the other Parts of that glorious Globe. If the Spots are of short duration, *Faculae* seldom ensue: Or if they do, they are commonly the Remains of some Spots that had before been on the Sun, and vanish'd perhaps on the side opposite to us. But Spots that long continue, if they vanish before that part of the Sun revolveth out of our sight, do very often become *Faculae*. Of which the Table affordeth several Instances, particularly *July 3. 1705.*

From these preceding Particulars, and their congruity to what we perceive in our own Globe, I cannot forbear to gather, *That the Spots on the Sun are caused by the Eruption of some new Vulcano therein*; which at first, pouring out a prodigious quantity of Smoak, and other opacous Matter, causeth the Spots: And as that fuliginous Matter decayeth and spendeth itself, and the Vulcano at last becomes more torrid and flaming, so the Spots decay and grow to *Umbrae*, and at last to *Faculae*; which *Faculae* I take to be no other than more flaming
brighter

brighter Parts than any other Parts of the Sun. These *Faculae* I have observ'd never continue long on the Sun : And the reason I conceive is, because the *Vulcano*, after its Smoak is over, doth not long emit its Flames ; by reason the fiery *Pabulum* is then near spent, when once it begins to flame : After which the torrid *Vulcano* soon returneth to the Natural Temperature of the Sun, so nearly at least as to escape our sight, at so vast a distance as the Sun is from us.

Another thing that may be accounted for, and indeed doth in some measure confirm also what I have said, is the *Nuclei*, or darker part of the Spots ; generally in most Spots, and towards the middle of them. Now it is very usual in Culinary Fires in this our Globe, when they emit Smoak, that the middle is the darkest part. If, for Instance, we were from aloft in the Air, to see a thick Smoak come tumbling out of a *Chimney*, or the Mouth of a *Vulcano* just kindled, we should find the middle part, just over the Mouth of the *Chimney*, or *Vulcano*, to be the most spiss and dark, and towards the extremes clearer and thinner. And so I take it to be in the Eruptions of the Sun ; that the *Nucleus* is just over the Mouth of the ignivomous Cavern, and that the misty Parts of the Spot are the thinner Parts of the Smoak, swimming about in that Fluid, or *Atmosphere*, which I suppose doth surround the Sun, as well as our Globe, and the Moon manifestly ; yea, and in all probability, every Planet of this our Solar System.

From what hath been said, we may give a reason why there are sometimes Spots frequently on the Sun, and sometimes none in many Years. One thing I believe there is in this, That there may be Spots, but not always seen. But there are doubtless great Intervals sometimes when the Sun is free ; as between the Years 1660 and 1671, 1676 and 1684. In which time Spots could hardly escape the sight of so many curious Observers

servers of the Sun, as were then perpetually peeping upon him with their Telescopes in *England, France, Germany, Italy*, and all the World over; whatever might be before, from *Scheiner's* time. The reason, I say, of this long disappearance of the Spots, I take to be from the want of extraordinary Eruptions in that fiery Globe. The Sulphureous, or other Matter, or *Pabulum* of those Eruptions, is spent or dissipated, and that Globe continues in its natural ordinary burning State, till there happens to be a fresh Collection of Smoaking, Displosive, and extraordinary Matter, that causeth a new Eruption. Which Eruptions generally happen between what we may call the Sun's Tropicks, or in his Torrid Zone: For I never observ'd any Spots to be near the Sun's Poles. And if I misremember not, the Spots in *Scheiner's* Cuts are all about the middle Zone of the Disk. The greatest Evagation I ever observed of them was *March 8. 1703*. On which Day, besides the dark Spots in the usual Zone, I perceived some faint Spots, scarce visible, much nearer the Southern Pole than I ever had seen them. But this was, no doubt, in some measure owing to the Position of the Earth in respect of the Sun, as well as to the Southerly Place of the Spots on him: For, about the Equinoxes, the Spots seem to march pretty far towards the Poles of the Sun, as may be seen by the annexed Schemes. (*Tab. II.*)

Having thus observ'd what part of the Sun the Spots commonly possess, I shall next take notice of their *Stages* and *Path* over the Sun. That the Sun moveth round his own *Axis*, is manifest, beyond doubt, from the Motion of the Spots. And that the Spots seem to traverse the Sun, sometimes in Strait Lines, sometimes in Curve Lines, curved this way, and that way, is as manifest also, and well known to the Curious, and is set forth in the annexed two Figures: Which Figures shew the Stages of the Spots every Day that I observ'd them,

and

and the Lines they describe in several Months of the Year. The daily Stages in both Figures are exact; or if they seem otherwise, it is by reason the Observations were made at different times of the Day; as one in the Morning, the other some following Day in the Evening, or Afternoon. But the Declinations of the Spots, or their distances from the Suns Northern or Southern Limb, are less exact in the second Figure than the first; in which latter they are very near the truth.

And the Causes of the Defects in the 2d Scheme I shall mention, to prevent the same Errors in others I my self ran into.

1. The Diminution of the Suns vertical Diameter by the Refractions was the principal cause of my Errors. This, altho' I was sufficiently aware of, yet I did not think had been so considerable, for want of experimenting, or well considering the Matter: For I have sometimes found the perpendicular, or vertical Diameter of the Sun diminished, from $32' 21''$ on the Meridian, to $26' 3''$ at the Horizon, in one and the same Day.

2. For the same reason I was not aware of the time being so long before the Sun goes round, as I found it.

3. Another Error was measuring the Suns Image on the Scene of white Paper, with the Shade of the Micrometer; and not by looking through the Tube, and so clasping the Limb of the Disk with the parallel edges of the Micrometer. The former, altho' practised by some eminent Astronomers, is a far more easy and indulgent, than accurate way.

*A further Account of the Solar Spots to the
Year 1711.*

SINCE my foregoing Account was drawn up, I have seen other Spots on the Sun, whose times are expressed in this following Table.

1707.	1709.
Decemb. 4	Jan. 15
10	21
* 29	22
* 30	August 13
	* 17
1708.	Octob. 8
July 31	Novemb. 1
August 1	2
5	4
6	5
22	6
23	
24	1710.
28	Jan. 22
Septemb. 1	April * 6
Novemb. 5	Octob. 14
Dec. 14	* 18
26	

From the Spots in this Table I had frequent occasions to be assured of my Opinion, in the foregoing Paper. Particularly in viewing the Spots of *August 1. 1708.* (represented in *Tab. II. Fig. 3.*) where some were large and dark, others

others less and thinner, and all encompass'd with *Nebulae*: In viewing these, I say, I observ'd great alterations at the very time I was looking on them. Sometimes the *Nuclei* were very dark and black, sometimes less so; and the same thing I observed also in the *Nebulae* encompassing them: One of the lesser Spots *b.* in *Fig. 3.* which the Day before was sufficiently visible and strong, was this Day, now thick and strong, and anon languid and less visible. And from the two Spots *a.* and *d.* I could plainly see a Smoak issuing out to *c.* and *f.* sometimes visible for 5 or 6 Minutes, and then disappearing for a quarter of an Hour, or more; and then again smoaking out, and again disappearing, as before. All which Particulars, I saw over and over again repeated, for a good while together, till I was weary of the Observation.

These Spots I was hindered from viewing until *Aug. 5.* following: And then I found the Spot *b.* quite extinct, (as I expected,) as also some of the other Spots; together with the *Nebulae* grown less. But the great Spot *a.* continued dark and strong, only sometimes fainter, and then again stronger; and sometimes like a half, or horned Moon; sometimes roundish, or rather of an Oval Figure; of which latter Figure they commonly are, when they are near the Suns Limb, which this Spot was not far off at this time.

These particulars are Confirmations of what I said, *That the Solar-Spots are no other than a Smoak rising out of the body of the Sun.* Of which Opinion I have been almost ever since I first observ'd them, and find that I am not singular in this Opinion, as I shall shew from a Letter (which with some others is lately fallen into my Hands) from the admirable Mr. *Crabtree* to the no less admirable Mr. *Gascoigne*, the Inventor of the Micro-meter; which I presume will hardly be ungrately to this most illustrious Society.

The beginning of the Letter hath been torn off; but I find by that part of it that is left, it was Mr. *Crabrie's* first Letter to Mr. *Gascoigne*, and that the torn part was only Compliments for his Writing to him, being a Stranger, &c. After which it follows in these Words.

“ I writ also to Mr. *Townley* at that time my Opinion
 “ in brief of the Suns Spots, (which you conceive to be
 “ Stars.) and it seems he, or Mr. *Kay*, writ to the same
 “ purpose to you, desiring your Opinion: Which you
 “ freely deliver; for which I cannot but commend you,
 “ and especially for preferring Reason before any Mans
 “ Authority. Yet give me leave (*pace tua Amice deside-*
 “ *ratissime*) to speak my mind likewise freely concerning
 “ these Appearances. I do not value the Authority
 “ of *Galileus* (though reputed the greatest Speculative
 “ Mathematician in Europe) nor yet *Kepler* (though
 “ *Astronomorum facile princeps*) further than either De-
 “ monstrative, or the most probable Reasons confirm
 “ their Opinions. Nor will I stick to subscribe to the
 “ Man whosoever shall bring better Reasons for his O-
 “ pinion. I must acknowledge you say more for the
 “ stellifying of these Solar Obscurities, than I have heard
 “ before; yet I conceive not sufficient, either demon-
 “ stratively or probably to countermand those which
 “ *Galileus*, *Kepler*, and others have produced to the
 “ contrary; nor yet such as can be cleared from such
 “ Objections, as Reason, Demonstration, and Observa-
 “ tion may lay against them. My Occasions will not
 “ admit a full Disquisition hereof at this time; yet
 “ something I would say for the present, the better to
 “ furnish you where to object when I see you; that
 “ so by diligent Inquisition, the desired truth may
 “ (may we have that happiness) be better found out
 “ by us.

“ I have often observed these Spots ; yet from all
 “ my Observations cannot find one Argument to prove
 “ them other than fading Bodies. But that they are
 “ no Stars, but unconstant (in regard of their Genera-
 “ tion) and irregular Excreescences arising out of, or
 “ proceeding from the Suns Body, many things seem to
 “ me to make it more than probable.

“ For first, for their Form ; they are seldom round,
 “ but of irregular Shapes, and, as I have often seen, one
 “ side, or end of the Spot more thin than the rest, like
 “ to a certain misty darkness, and by degrees thicker,
 “ grosser, and darker, nearer to the main body of the
 “ Spot ; just as the Smoak of some pitchy Fire, which
 “ is in one part very gross, and in another more rare
 “ and thin, turning at last into meer Air : Or like a
 “ Cloud, Fog, or Mist, more thick, dark, and gross in
 “ the midst ; and more thin, fluid, penetrable, and tran-
 “ sparent towards the sides ; which I suppose is not
 “ compatible with any of the Stars.

“ Secondly, for their Colour : The lighness thereof
 “ differenceth them from Stars, or Planets ; they being
 “ never of such absolute darkness as I observed *Venus*
 “ the 24th of *November* last : Tho’ I have seen spots
 “ sometimes little less than she, yet always of a far
 “ paler and whiter Colour, looking (at least in some
 “ Parts) like some thin dissipated substance.

“ Thirdly, for the manner of their appearance. I
 “ have seen many Spots, which in the middle of the
 “ Sun appear of a round body, but coming towards the
 “ side of the Sun, appear long. Which (if you rightly
 “ consider it) is a demonstrative Argument that they are
 “ not Globes, as all the Planets and Stars are : For
 “ Globes always appear of one form (round) in every
 “ Position ; but Exhalations, or such like fluid Sub-
 “ stances, extended to a broad flat form, like our Clouds,
 “ which being over our Heads, and so in their full
 breadth,

“ breadth, appear large and broad; but driven with
 “ the Wind, till they turn one edge upon us, seem of
 “ a long shape. So these Solar-Clouds, being turned
 “ about the Sun, may in the middle shew their full
 “ breadth to us, and about both edges of the Sun, turn
 “ their edges to us: Which answereth to the appear-
 “ ance.

“ Fourthly, for their continuance. Some of these
 “ Spots, arising at the East-side of the Sun, vanish be-
 “ fore they come to the midst of the Sun. Others ap-
 “ pear first in the middle of the Sun, and vanish before
 “ they come to the Western Limb; and for the most
 “ part they vanish before they have made a full revo-
 “ lution about the Sun. Which argues them to be but
 “ thin, vanishing, fading Substances, not like the perma-
 “ nent bodies of the Stars.

“ But to take off these Reasons, you answer, That
 “ you conceive these Spots to be Stars moving regularly
 “ in their own Orbes, which are many, though none of
 “ greater extent than about $\frac{1}{10}$ of the \odot Semidiameter
 “ from its Circumference; and that the swifter Movers
 “ in the lower Orbes, overtaking the slower in the
 “ higher Orbes, cause an appearance. You seem there-
 “ fore to think, that they being so thin bodies, the
 “ Suns Rayes pass through them, and so one cannot
 “ be seen alone, till more being together, one heaped
 “ behind another, they stop the light of the Suns Rayes,
 “ and so cause an appearance. This I conceive is you
 “ meaning: Or else (as you seem to insinuate afterwards)
 “ that the Higher reflects the Suns Rayes strongly e-
 “ nough upon the Lower (when they come within the
 “ Angle of Reflection) to make the interjacent Planet
 “ indiscernable.

“ But to these I answer,

1. “ If it be by their coming within the Angle of
 “ Reflection, that the light of the Sun reflected from
 “ the

“ the outer Planet upon the inner, doth make it (as you
 “ speak) indiscernable, then that Light so reflected is re-
 “ flected either upon all places, as the Moons and Pla-
 “ nets Light; or but upon one, as is the Reflection
 “ of a plain Looking-Glass. If the first, there would
 “ never be many seen (seldom above one or two) be-
 “ cause the outermost would continually make the in-
 “ ner indiscernable. But *Gassendus* affirms, there are
 “ seen sometimes 40 at once in the Suns body. If the
 “ 2d, there would always be many seen, because the
 “ reflected Light would but occupy a little room, and
 “ that but for a small time, till the swifter were past
 “ the place of Reflection: Whereas many Days there
 “ are none at all seen in the Suns Hemisphere: And in
 “ both these cases, the outermost Planet of all would
 “ always in the space of 27 Days, be seen in the same
 “ place, being never obscured, none of the inferior be-
 “ ing able to reflect Light upon it. Add hereunto, if
 “ any kind of Reflection should make them to appear
 “ bright like the Sun, and so not distinguishable from
 “ the Light of the Sun, what should (a) hinder, but
 “ we should see them also bright Bodies by the side of
 “ the Sun, when they are passing either by the West,
 “ or East-side of the Suns Body? The Light being
 “ then reflected upon them by the inferior Planets as
 “ well as at other times, and that also upon much of
 “ that side of them which we should behold.

(a) N. B. Mr Gascoigne having, against these Words, insert-
 ed a rough-drawn Figure in the Margin of Mr Crabtree's Let-
 ter, I have also represented it in Tab. 2. Fig. 4. imagining it may
 somewhat explain Mr Gascoigne's Hypothesis, and what Mr.
 Crabtree saith against it.

But

“ But if you wave this conceit, as insufficient, and fly
 “ to your former, That the swifter Movers in the
 “ lower Orbes, overtaking the slower in the higher
 “ Orbes, cause an appearance. To this I answer.
 “ 1. The thing you suppose seems to me neither ne-
 “ cessary nor probable, nor do I conceive why they
 “ should not be seen, being themselves alone, as well as
 “ conjoined, seeing all other Stars and Planets are so.
 “ 2. If it be because they are of a thin, transparent
 “ Substance, till many, being one behind another, make
 “ them to seem grosser; Then they are not of the
 “ nature of other Planets, as is proved in γ and δ ,
 “ who of themselves appear dark Bodies, when they
 “ come between us and the Sun; nay, they must be
 “ more thin than our Clouds, which will easily be seen
 “ between us and the Sun, and hides it from us. 3. If
 “ it be because they are so little, that the Imperfection
 “ of our Glasses cannot discover one alone, there must
 “ be, without doubt, many Millions of them; which
 “ how they can be included within the compass of $\frac{1}{10}$
 “ of the \odot Semidiameter, we shall consider anon. I
 “ have seen one of an ordinary darkness, (yea darker
 “ than many greater) yet not above 5" Diameter. If
 “ this consist of two, or many, of themselves invisible,
 “ how many were in those which *Gassendus* saw of $1\frac{1}{2}$
 “ Diameter? 4. The Figure of these great ones (being
 “ necessarily composed of Stars of such different Orbes
 “ and Motions) would quickly vary, by reason of the
 “ diversity of their Motions; like-as we see in a Flock
 “ of small Birds. But 5thly, you say the furthest of
 “ these Orbes is not above $\frac{1}{10}$ of the Sun's Semidiameter
 “ from its Circumference. But there would not, in that
 “ small space, be room enough for so many Orbes of
 “ Planets, as have been seen at once. Which I prove
 “ thus. 1. *Gassendus* affirms there are sometimes some
 “ of about the $\frac{1}{10}$ part of the \odot Semidiameter; which
 “ is

« the whole space allowed by you for them all. And
 « I my self have seen of $\frac{1}{15}$ of the ☉ Semidiameter : And
 « yet you must confess these great ones could only be
 « the Conjunctions of some, not all. 2: There are
 « many times seen in the ☉ Superficies, a great number
 « of Spots, whose Diameters added together, would
 « do more than twice fill the space you speak of. I my
 « self have seen it, and so I believe have you. *Gas-*
 « *sendus* affirms, there are sometimes 40 seen at once :
 « If this was by Conjunction of Planets, in every Ap-
 « pearance, there was at least 80 Bodies at once on this
 « side the ☉ ; it may be as many on the other side,
 « besides those unseen (by your Reflection or other-
 « wise) which doubtless must be far more than seen.
 « For it is a most rare, and I think unheard of thing
 « to see but 3 (which is less than the half) of our
 « Planets, conjoin'd in visible δ at once : So that with-
 « out question, if they be Planets, they are many hun-
 « dreds ; which must have so many several Orbes, and
 « which certainly cannot be done in so narrow a com-
 « pass, as the $\frac{1}{10}$ of the ☉ Semidiameter. And that
 « they cannot have any larger (I suppose not so large
 « an) extent from the ☉ Superficies, may be proved by
 « their motion through the visible Hemisphere of the
 « Suns Spherical Body, by comparing the swiftness of
 « their motion towards the middle and sides together.
 « 6. If one of these (imagined) Planets be swifter than
 « another, as they must needs be, then the δ of 2 or
 « 3 swifter ones would make a Spot of speedier motion
 « than the δ of 2 slower ones : But the motion of all
 « about the ☉ Center, is always equal ; yea, and the
 « Spots retain the same Position one to another, (con-
 « sidering the Suns Sphericity, and the Angle of their
 « appearance to us) just like the Fixed-Stars. So affirms
 « *Gassendus*, *Moveri omnes eodem & uniformi motu, adeo*
 « *ut, cum plures fuerint, nulla anteveriat aliam, sed cun-*

“ *dem tenorem in disco ☉ perinde seruent inter se, ac*
 “ *seruant Fixæ in firmamento.*

“ As for that other annual Motion of the Spots, you
 “ speak of, from West to East, upon their Axis inclin-
 “ ed above 8 Degrees to the Ecliptick; I suppose it is
 “ not any real Motion of the Orbes of those Solar Pla-
 “ nets or Spots, but only a visible Motion so appear-
 “ ing, caused (in *Kepler's* Systeme) by the Suns rolling
 “ upon its own Center in the midst of all the Orbes,
 “ not exactly in the way of the *Temporary* Ecliptick,
 “ but in the *Via regia* (as *Kepler* calls it) inclined certain
 “ Degrees to the *Temporary*; thereby turning about with
 “ him, the same way, his Adventitious, or Excrementi-
 “ tious Parts, the Spots, by his *Magnetical* or *Sympathe-*
 “ *tical* Rays. And hence may be demonstrated the
 “ appearance of that Annual Motion in the Suns Spots
 “ you speak of. See *Galileus, Syst. Cosm. p. 339, & seq.*
 “ So also in *Ptolemie's* and *Tycho's* Systeme, the same Ap-
 “ pearance may be demonstrated, supposing the ☉ fixed
 “ in the middle of the Universe, and the ☉ rolling
 “ round upon the same Poles of that *Via regia* (or way
 “ of the Spots) and keeping his Axis in Parallelism con-
 “ tinually towards one and the same Part of the Uni-
 “ verse. This may be certainly demonstrated, altho'
 “ *Galileus* there affirms the contrary. Other *Hypothe-*
 “ *ses* of that Motion may be feigned, as by the annual
 “ conversion of the Poles of the *Via regia* about the
 “ Poles of the Ecliptick in the Suns Body: But none I
 “ conceive so compendious, as the one of the former.
 “ For my part, I incline to the first: Yet if when we
 “ see you, you shew us any more likely Theory, for
 “ my part I shall be ready to consent to you in any
 “ thing with reason.

“ Thus you have, what for the present, I conceive
 “ of these *Maculæ Solares*. *Fromundus* mentions one
 “ *Jo. Tarde Gallus*, who thinks them to be Secondary
 “ Planets;

“ Planets; who hath written a Book of that Subject,
 “ and calls them *Astra Borbonia* : But I could never yet
 “ see it. What you, or he, or others may alledge for
 “ that Opinion, I know not. In the mean time it
 “ were too much levity in me, against my Judgment,
 “ to acknowledge them Stars; unless I see at least
 “ some possibility how they may be so, or some pro-
 “ bability why they should not rather be Spots. Which
 “ when you, or they do produce from better grounded
 “ Reasons, Optical Experiments, or Demonstrations, I
 “ shall willingly recant my Opinion.

“ In the mean time, let me encourage you to pro-
 “ ceed in your noble Optical Speculations. I do be-
 “ lieve there are as rare Inventions as *Galileus Tele-*
 “ *scope*, yet undiscover’d. My living in a place void
 “ of apt Materials for that purpose, makes me almost
 “ Ignorant in those Secrets; only what I have from
 “ Reason, or the reading of *Kepler’s Astron. Opt.* and
 “ *Galileus*. If you impart unto us any of your Op-
 “ tical Secrets, we shall be thankful, and obliged to
 “ you, and ready to requite you in any thing we
 “ can.

“ It is true which you say, That I found *Venus*
 “ Diameter much less than any Theory extant made
 “ it. *Kepler* came nearest, yet makes her Diameter 5
 “ times too much. *Tycho*, *Lansberge*, and the Ancients,
 “ about 10 times greater than it was. So also they dif-
 “ fer in the time of the δ as far from the truth. By
 “ *Lansberg* the δ should have been $16^h\ 31'$ before we
 “ observ’d it : By *Tycho* and *Longomontane* $1^d\ 8^h\ 25'$ be-
 “ fore. By *Kepler* (who is still nearest the truth) $9^h\ 46'$
 “ before. So that had not our own Observations, and
 “ Study, taught us a better Theory than any of these,
 “ we had never attended at that time for that rare
 “ *Spectacle*. You shall have the Observation of it,
 “ when we see you. The Clouds depriv’d me of part

“ of the Observation, but my Friend and second Self
 “ Mr. *Jeremiah Horrox*, being near *Preston*, observed it
 “ clearly from the time of its coming into the Sun,
 “ till the Sun’s setting ; and both our Observations a-
 “ greed, both in the Time and Diameter, most precisely.
 “ If I can, I will bring him along with Mr. *Towneley*
 “ and my self, to see *Yorkshire*, and you. You shall
 “ also then have my Observation of the Sun’s last E-
 “ clipse here in *Broughton*, Mr. *Horrox*’s between *Liver-*
 “ *poole* and *Preston*, and Mr. *Foster*’s at *London*. *Langs-*
 “ *berg* in Eclipses, especially of the ν , comes often
 “ nearer the truth than *Kepler*, yet it is by packing
 “ together Errors ; his Diameters of the \odot and ν be-
 “ ing false, and his variation of the Shadow being
 “ quite repugnant to Geometrical Demonstration. His
 “ circular Hypotheses Mr. *Horrox* (before I could per-
 “ swade him) assayed a long time with indefatigable
 “ Pains, and Study, to correct, and amend ; changing
 “ and turning them every way (still amazed and amused
 “ with those lofty Titles of Perpetuity and Perfection,
 “ so impudently impos’d upon them) until we found,
 “ by comparing Observations in several places of the
 “ Orbes, that his Hypotheses would never agree with
 “ the Heavens for all times, as he confidently boasts ;
 “ no, nor scarce for any one whole Year together, al-
 “ ter the equal Motion, Prosthaphæreses, and Excentric-
 “ ity howsoever you will.

“ *Kepler’s Elliptick* is undoubtedly the way which
 “ the Planets describe in their Motions: And if you
 “ have read his *Comment. de motu 3^o*, and his *Epit.*
 “ *Astron. Copern.* I doubt not you will say his
 “ Theory is the most rational, demonstrative, harmo-
 “ nious, simple, and natural that is yet thought of,
 “ (or I suppose can be ;) all those superfluous Fictions
 “ being rejected by him, which others are forced so
 “ absurdly to introduce. And although in some respects
 his

“ his Tables be deficient, yet being once corrected by
 “ due Observations, they hold true in the rest: Which
 “ is that argument of Truth, which *Lansberge's* and all
 “ others want.

“ Your conceit of turning the Circle into 100,000,000
 “ Parts, were an excellent one, if it had been set on
 “ foot, when Astronomy was first invented. Mr. *Hor-*
 “ *rox* and I have often conferred about it. But in re-
 “ spect that all Astronomy is already in a quite diffe-
 “ rent form, and the tediousness of reducing the Ta-
 “ bles of Sines, Tangents, and all other things we
 “ should have occasion to use, into that form; as also
 “ some Inconveniences which we foresaw would follow
 “ in the composing the Tables of Celestial Motions,
 “ together with the greatness of the Innovation, de-
 “ terred us from the conceit. Only we intend to use
 “ the Centesmes or Millesmes of Degrees, because of
 “ the ease in Calculation. I have turned the *Rudol-*
 “ *phine* Tables into Degrees and Millesmes, and altered
 “ them into a far more concise, ready, and easy form,
 “ than they are done by *Kepler*. My Occasions force
 “ me to put an abrupt End to my unpolish'd Lines,
 “ and without more Compliments, to tell you plainly,
 “ but sincerely, I am

Your Loving Friend,

*From my House in
 Broughton near
 Manchester, this
 7. August 1640.*

(though de facie ignotus)

WILLIAM GRABTRIE.

The Superscription of this Letter is, *To his Loving
 Friend Mr. William Gascoigne, at his Fathers House in
 or near Leeds in Yorkshire.*

This

This with most of the Letters between Mr. *Crabtree* and Mr. *Gascoigne*, together with other very valuable Papers of Mr. *Horrox*, Mr. *Towneley* himself, Mr. *Collins*, Mr. *Shuse*, and other great Men, were imparted unto me, the last Month, by the great favour of *Charles Towneley Esq;* Son of the late most Ingenious *Rich. Townley Esq;* of *Lancashire*.

And forasmuch as every thing of Mr. *Crabtree's* is valuable, I have taken this occasion from my own Observations of the Solar Spots (for the most part drawn up near 4 Years ago) to give Mr. *Crabtree's* Letter at large, containing as well some things of another Nature, as what relates to the Spots; not doubting but the one will be acceptable to the Curious, as well as the other. I have two other of his Letters concerning the Spots (with Mr. *Gascoigne's* Answers.) One contains his Theory of their Motion and Appearances; the other his way of observing them. But being long, I have not time at present to fit them up for the Societies Use; but intend (God willing) to do it as soon as may be, if this Specimen be acceptable.

N. B. Tab. II. Fig. I. Shows the Stages and Lines described by the Spots upon the Sun in Sept. and Novemb. 1706. and in Feb. and March, 1707. and in Sept. and Novemb. 1707.

Fig. II. Shows the Stages and Lines described by the Spots upon the Sun in Jan. 1707. and in May, June, and Octob. 1705.

The other Figures in this Table are explained in the foregoing Discourse.